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WHITEPAPER

Developing Norms and Standards for Digital Olfaction

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It may not initially seem like smell plays a vital role in our daily lives, but from the moment we wake up to the moment we go to sleep, our noses influence how we perceive the world around us. In today's digital age, smell is also increasingly influencing technology. Specifically, we've seen rise of various digital olfaction devices, which aim to digitize and reproduce smells. Aryballe's own digital olfaction device combines biochemistry, advanced optics and machine learning to mimic the human sense of smell.

But we have a broader vision for our devices, and we are building a platform for our customers and partners to solve meaningful industry problems through odor data. In doing so, we are also working to solve the challenge of how to define and classify individual odors, especially in the face of little to no existing standards.

The following outlines our work in bringing norms and standards to the digital scent market, and how we aim to overcome some of the primary obstacles currently facing the advancement of digital olfaction.

What Is Digital Olfaction

The technology behind electronic noses, digital olfaction, is generally defined as the digital capture and display of aromas, and its applications are broad and far-reaching. Similar to our sense of smell, digital olfaction mimics the process by which our brains identify and differentiate between odors. But to understand how it works, we must first define odor.

Objects release odor molecules in response to temperature. When temperatures increase, evaporation of odor occurs, and it then becomes possible for humans to absorb this odor through their nasal cavities. This stimulates the neural system of the olfactory bulb, and using other information, such as memory, the olfactory cortex produces the final result: the smell of the object.

The olfactive receptors in the nose capture odors similar to how odors bind to biosensors in digital olfaction sensors. Once these odor signatures are obtained by the nose, the olfactory bulb together with the brain structures involved in memory create an association between the signature and the odor source. In digital olfaction, software interprets the signatures based on a database of previously collected and analyzed odors to act almost as our memory bank, to correlate individual smells to life experiences and learnings and then classifies the odor accordingly.

While the technology may not yet have the same sophistication of the human olfactory system, new advances are making it easier for companies to innovate and enter the space. Notably, we've seen several devices come to market that focus on air quality monitoring. Breathomix detects gaseous biomarkers through human breath and is currently addressing applications in identifying respiratory diseases. And Tellspec is focused on a hand-held spectrometer for detecting food quality and spoilage. But much of this technology is extremely large, expensive, has limited performance, and most important of all, suffers from inconsistency in identifying individual odors.

So while we continue to see advancement of digital olfaction technology as well as the entrance of more and more players in this space, developing norms and standards for the interpretation of olfaction data is becoming a key industry concern.

Our Technology

Aryballe has been working to digitally capture and mimic the human sense of smell for the last several years. We launched our NeOse Pro at CES in 2018, which uses a unique combination of biochemical sensors, advanced optics, and machine learning to mimic the human sense of smell.

The ultimate goal is to build the world's first universal scent database, which not only provides consistency in the definition and characterization of smell but will enable companies to use the data to inform key business decisions. Examples include rejecting or approving a raw material supply, reducing analysis time in the R&D formulation of a new beverage to see whether the new formula tastes similar to the original, or even alerting a driver their car is due for service based on odors in the cabin.

DETECTION OF ODORS

These solutions capture odor signals emitted by samples in the software platform as odor signatures. With olfactory measurements, compounds of interest can have varied level of dilution—and the sensor can have a varied level of sensitivity, or limit of detection, to particular odors. Using machine learning and detection of pure odors, we can develop models to better detect lower concentrations.

Aryballe has undertaken the task to set norms and standards for digital olfaction as the first step in building a truly universal database for odors.

Why Standards Have Been Hard to Define

Because of the complexity involved in defining and characterizing different smells, progress toward achieving standardization has been slower than expected. Olfaction is a contextual experience, defined by the environment and the human experience, and training a machine to do this – to achieve digital olfaction – takes supervised and unsupervised machine learning.

At the same time, different industries are interested in different odor molecules. Organizations within the Flavor & Fragrance industry will not be interested in the same odor molecules as organizations within the consumer appliances or automotive industries. Or, in cases where there is overlap, the interpretation of the results may be wildly different. For example, imperfections in perfume formulation versus overall perfume intensity.

But for the very same reason standardization is challenging, it's also necessary. Standards are needed to bring structure and clarity to a process that is highly subjective and requires context to make sense.

Our Approach to Standardization

Aryballe recognized early on that in order for olfaction sensors to become part of the smart sensor ecosystem, industry standards would be critical to defining how odor data should be interpreted and applied to various use cases. Given our work with the Digital Olfaction Automotive Consortium (DOAC), which we launched in 2019 alongside key automotive players with the goal of establishing standards for odor measurement in the automotive industry, we began working on a set of protocols based on the ISO 12219-7:2017 norm.

The protocol specifies a standardized and objective process to analyze and determine the olfactory behavior of components, semi-finished products and materials fitted in the interior of road vehicles. The odor determination is either performed by using samples from the interior air of road vehicles or from emission test chamber air. The standard recognizes that since olfaction is such a subjective assessment, the standardization of the process is extremely important.

This standard also describes the methods with which human panels are trained for the industry. By adapting the protocols to our instrument, we're able to train our equipment like the existing best-known method in this market—the human nose.

TEST METHODOLOGY

As a first step, Aryballe had to screen the level of sensitivity of the NeOse for a broad range of concentrations, for each compound cited in this norm. Compounds discussed are basic odor note profiles – not used in applications, but to create odor notes – as we are training our system the same way human panels are trained.

Within the experiment, Aryballe also established a signal/noise ratio and measured odor concentration in ppm provided by a PID sensor. A subjective human nose measurement was also recorded following the protocol given by the norm. Lastly, an Amplifier device was used to estimate the gain obtained with the pre-concentration of the sample as the combined devices (NeOse Pro + Amplifier) produce even greater sensitivity to all compounds tested.

SIMULATION

In each experiment, six dilution levels for each compound were analyzed (100%, 10%, 1%, 0.1%, 0.01%, 0%). Two runs were completed for each compound experiment, with a re-preparation of all the samples each time to avoid any dilution mistakes.

SELECTING A DILUTION METHOD

Liquid dilution is a perfectly fine method for most compounds to develop an adequate headspace for detection. 1 mL of each solution is prepared at the required dilution in the chosen solvent, which can be mineral oil, ethanol or water, given their miscibility.

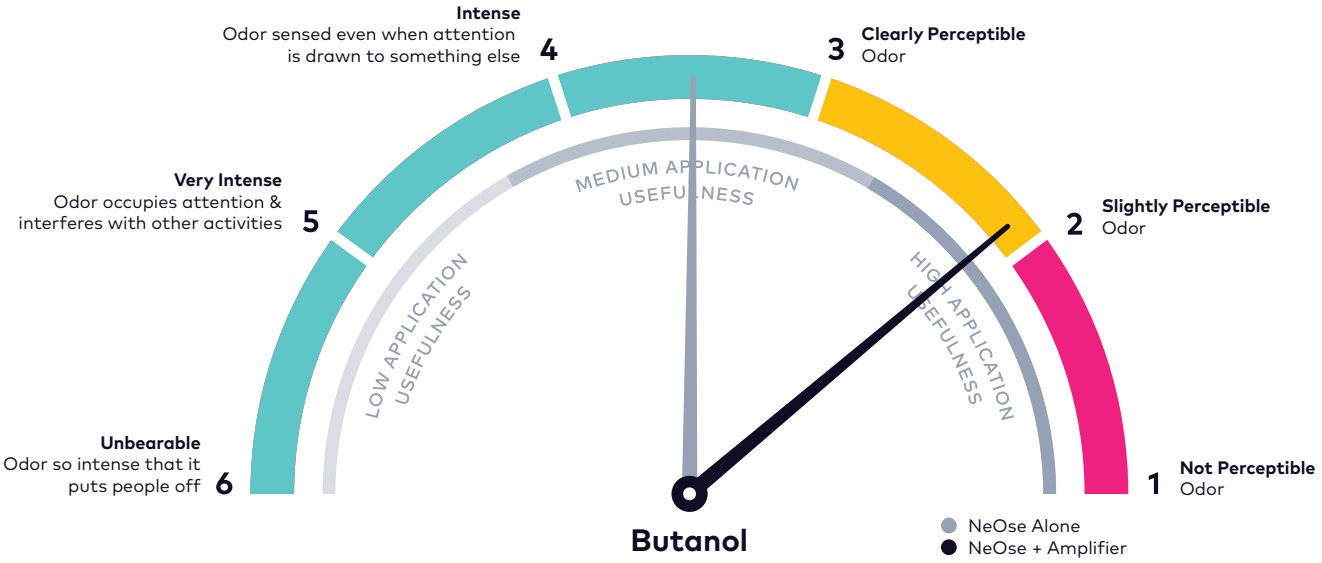
A total miscibility of the compound is needed to guarantee a consistent dilution level. If this state is not reached, the two phases (non miscible) of pure compound can be in contact with the gas phase while mixing, that can lead to a variable concentration of the headspace than the expected dilution. For these instances, where complete miscibility cannot be achieved with a liquid diluent, then using a gas dilution method is recommended.

Gas dilution requires a controlled mixing with clean air and the desired compound in the headspace. Just as with liquid dilution, this method requires considerations around temperature controls and using a secondary sensor, such as a PID, to detect the concentration levels.

While air dilution has the added benefit of avoiding high background noise that can occur with some liquid diluents (ethanol, water, etc.), this can be accounted for with post processing methods when using liquid dilution methods.

The outcome of these tests looks like Figure 1. These Odor Meter charts show the device performance as related to the sensitivity of the average human nose.

FIGURE 1



Conclusion

The adoption of digital olfaction continues to increase, and it will improve how numerous industries operate. Establishing standards will not only have the benefit of a wider base of users and lower barrier to entry, but will lead to new, innovative applications.

A lot of work remains to be done, but Aryballe is committed to building our odor database and representing device performance based on the human nose scale to set expectations for real-world applications. Our work with the ISO 12219-7:2017 protocol is just the beginning, and we'll continue to leverage our technology to bring norms and standards to the masses.

You can learn more about Aryballe's latest experiments by visiting the Aryballe website here, or by speaking with a member of our team.

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